



CFE Services

Requirements Development for Balloon Borne Sub- Millimeter Missions

In Support of NASA Phase I SBIR:
Low Cost CMB Telescope

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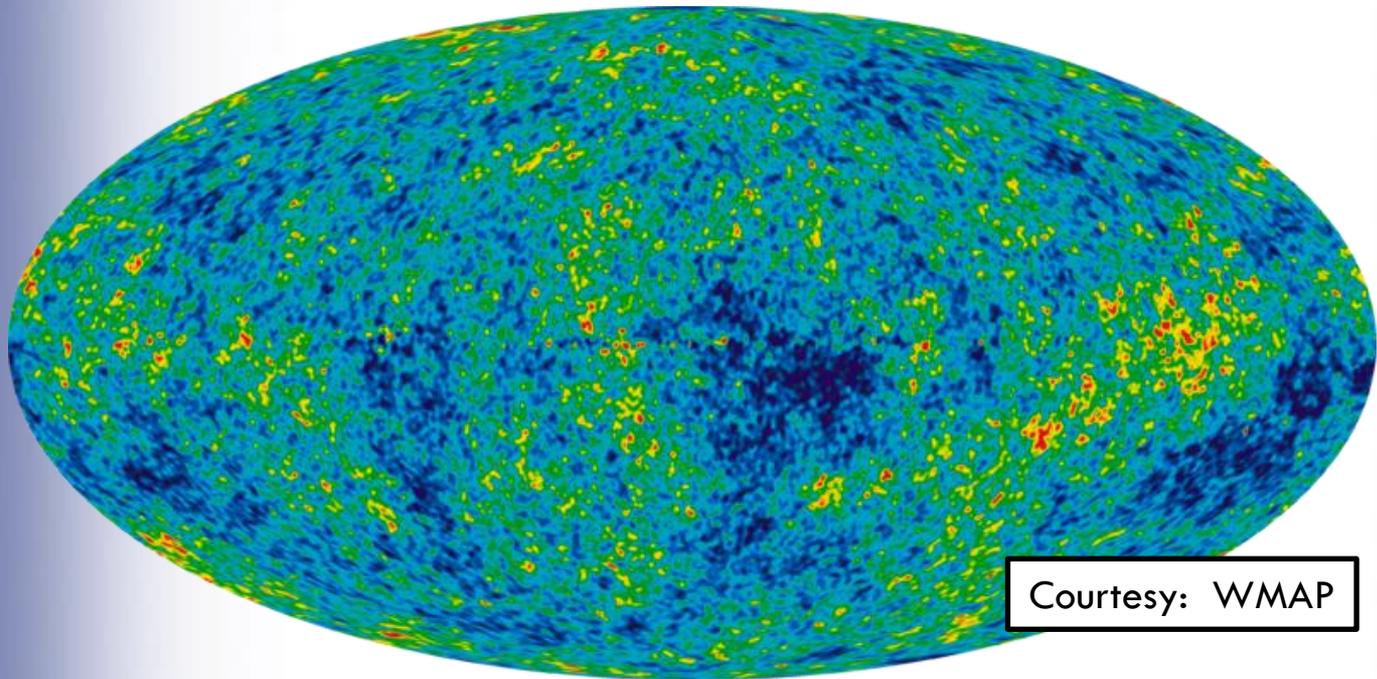
Motivation

- Far Infrared Observations hold the key to the Formation of Stars, Galaxies, the Universe Itself

- Observations include
 - Temperature maps of CMB
 - Spectroscopy of the Chemistry of Stellar Formation
 - Polarization Anisotropy

- Balloon Borne Platforms Advantages
 - Enable Groundbreaking Science
 - Prove Risky Technologies
 - Detectors Must be Flown on Balloon prior to Space
 - Rapid Deployment (2 yrs – Concept / Flight)
 - Low Cost (Approx. \$10 M)
 - Train Students

Extra-Galactic Temperature Maps

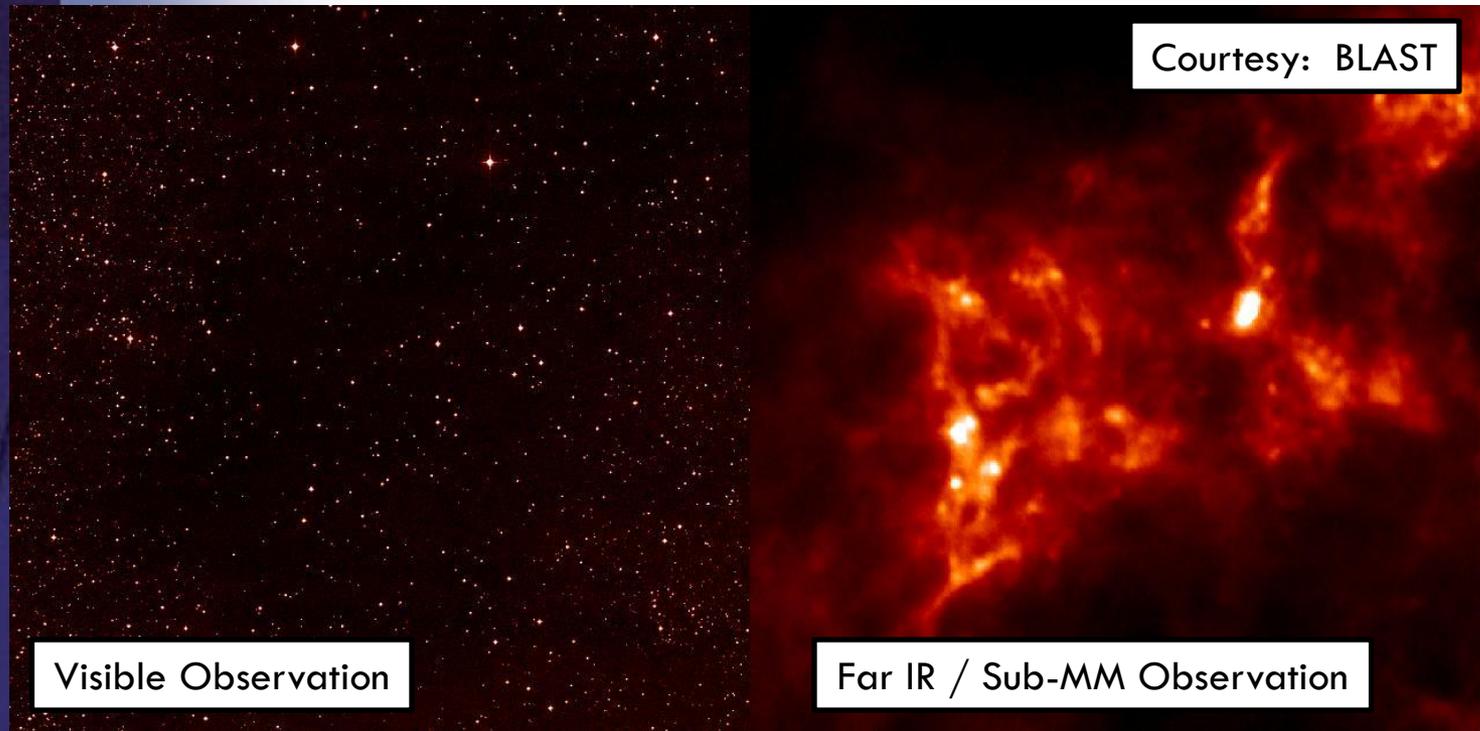


Courtesy: WMAP

All Sky Temperature Map

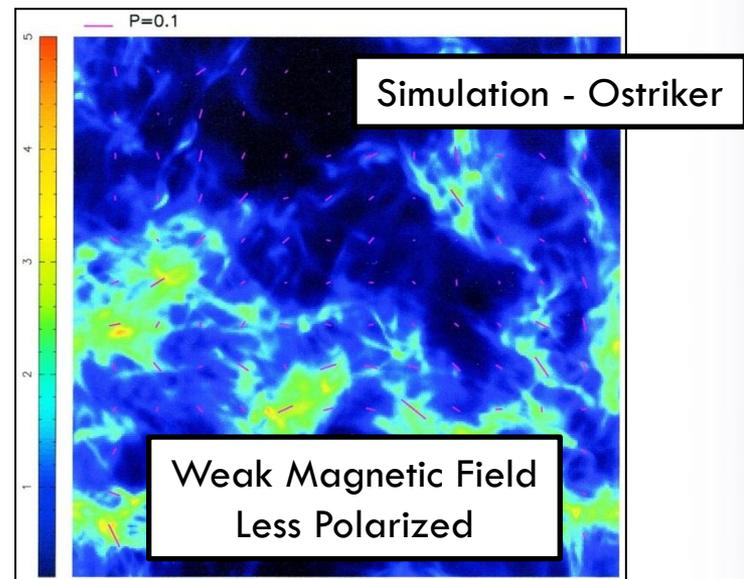
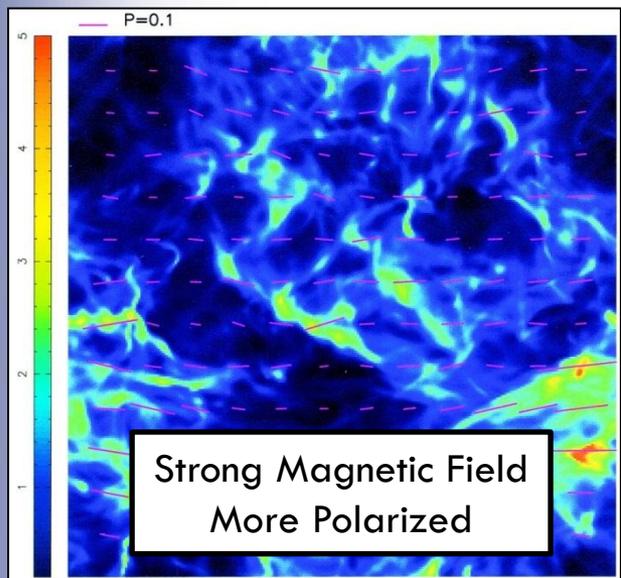
Early Star Formation

Cool Dust Clouds, Nearly Impossible to See with Visible Observations



Confirmation of Star Formation Theories

- Role of Magnetic Fields in Star Formation Theorized / Simulated
- Observations of Polarization in Far IR / Sub-MM can Confirm Theories



Where is this Science Being Discovered?

Ground



Space

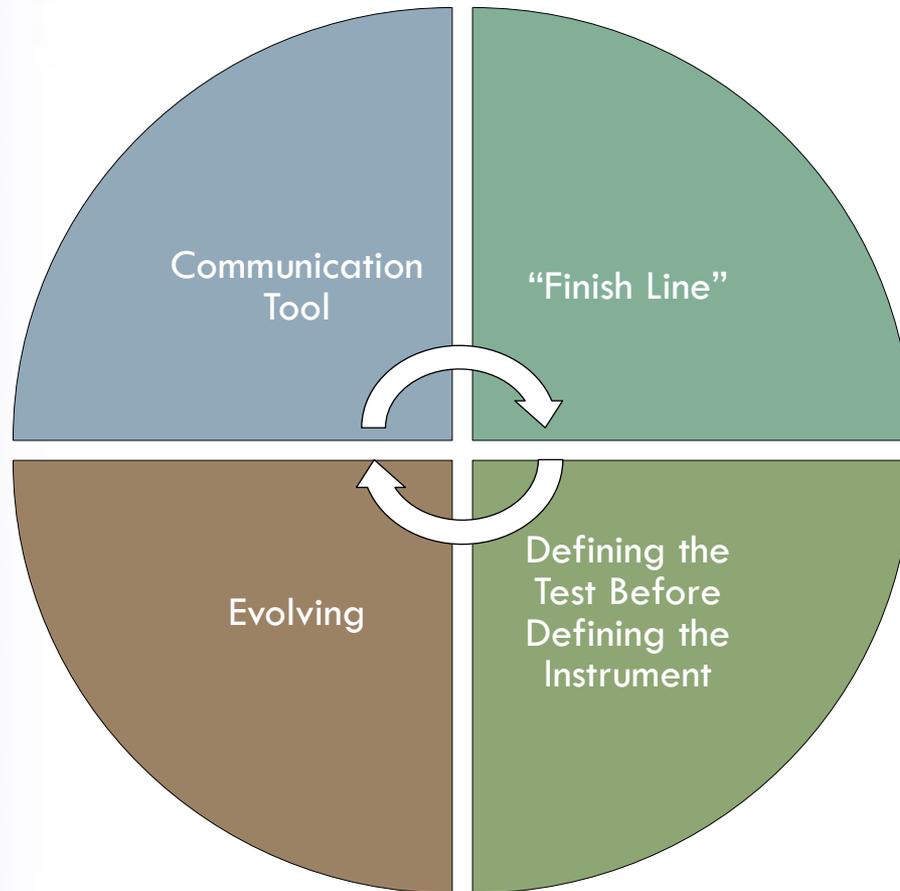


Air



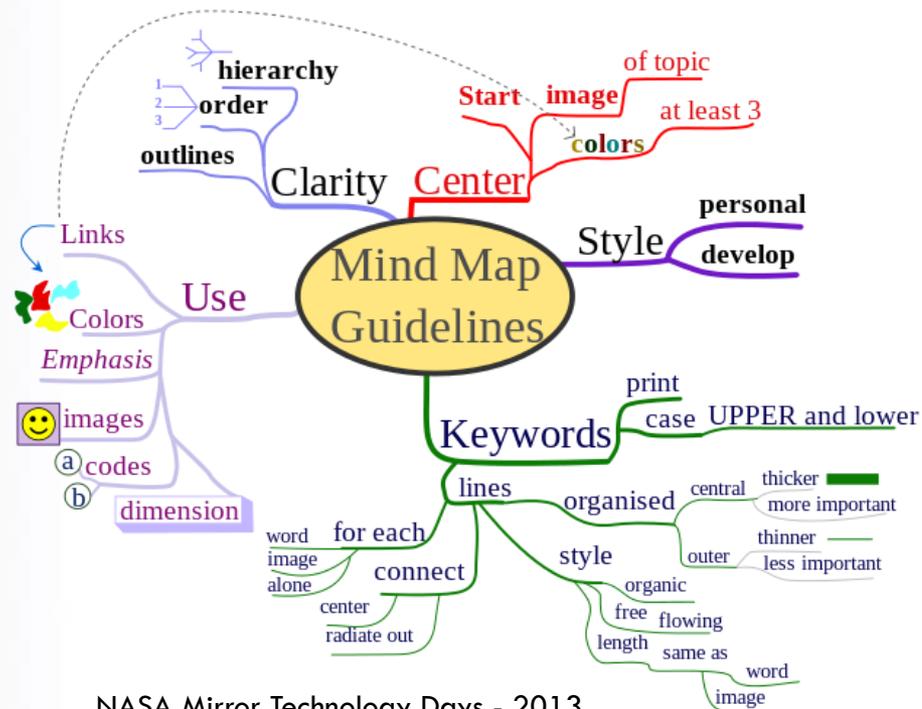
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Developing Requirements



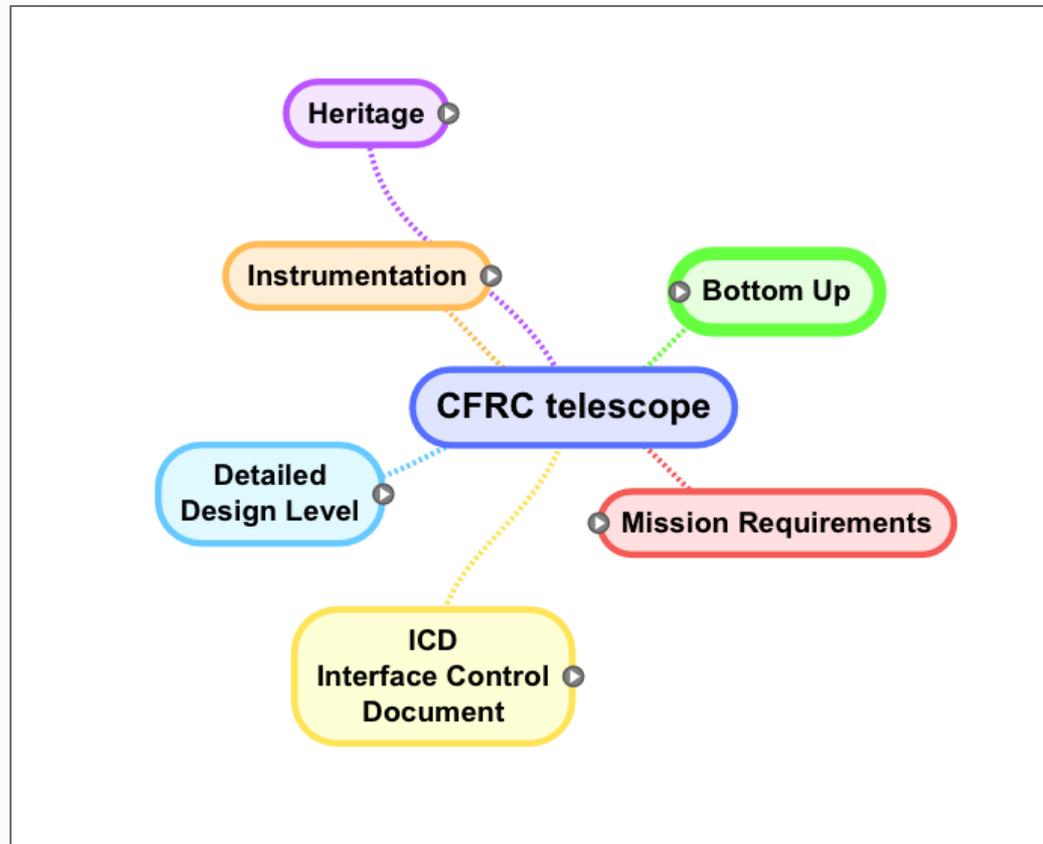
How Can We Pull All This Together?

- Mind Mapping as a Process
 - Brainstorming
 - Multi-Dimensional Outline
 - Cross Linking Ideas



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Initial Mind Map



Add Realism

- BLAST Launch
- BLAST Release

Launch



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Telescope Release



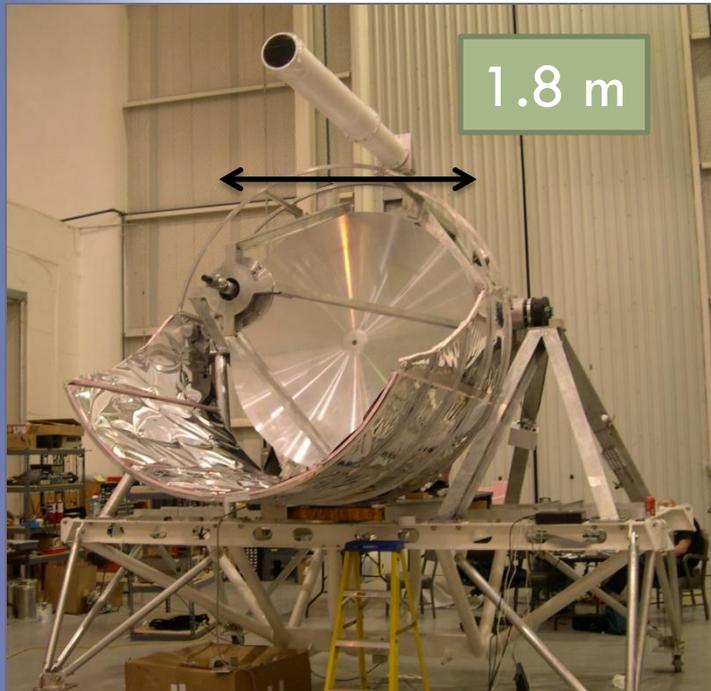
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Two Missions Under Study

- BLASTPol
 - Diffraction Limited
 - Follow-On from BLAST Missions
 - Small Object Observations
 - Imaging of Extended Sources

- MuSE
 - Cosmic Microwave Background (CMB) Imaging
 - Multimoded Imaging of Sky (5X Airy Diam.)
 - High Sensitivity
 - Extended Source Imaging

BLAST Heritage



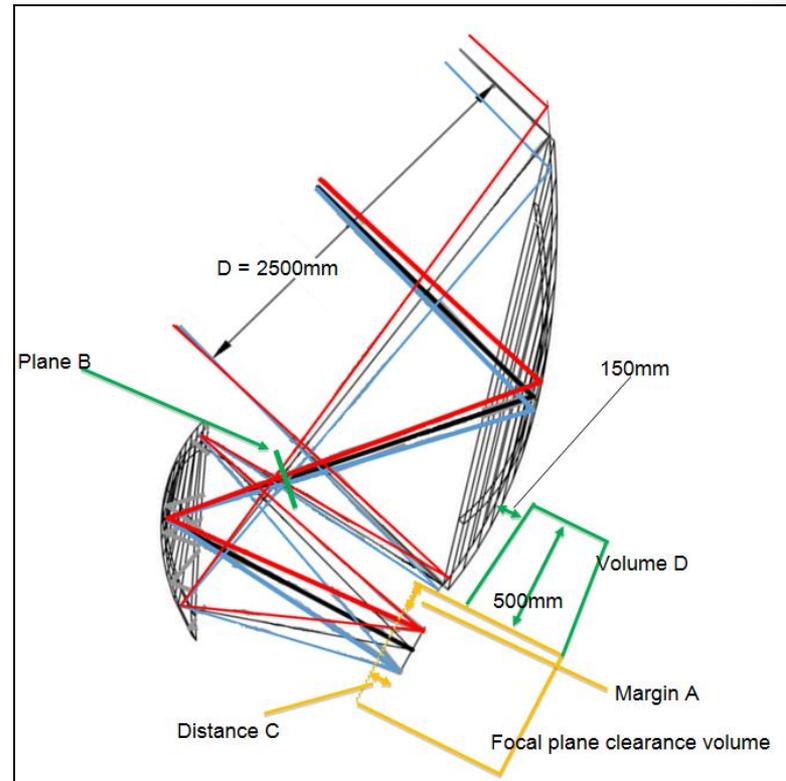
Balloon vs. Herschel Space Observatory

	BLASTPol / MuSE	Herschel
Cost	\$10M	\$1,400M
Observation Duration	2 wks	4 yrs
Approval to Launch	2 yrs	10 yrs
Wavelengths	200 μm to 7500 μm	80 μm to 670 μm
Telescope Diameter	2.5 m	3.5 m
Telescope Mass	100 kg	300 kg
Reusable	Yes	No

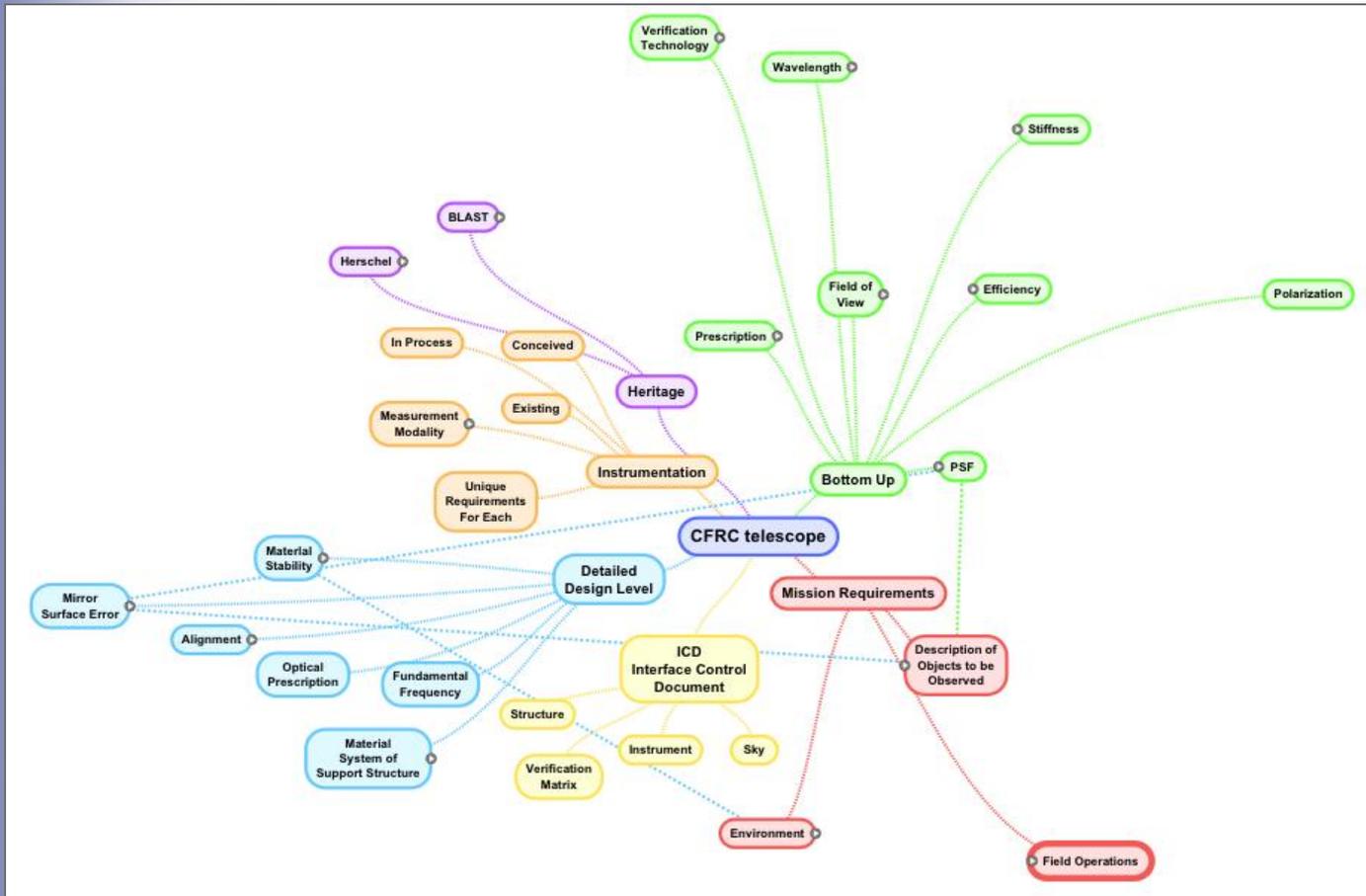


MuSE Reference Design

- Highly Off-axis
- Steeply Curved Conics



Intermediate Mind Map



Summary of Final Requirements

Req.	Value	
Release Loads	5 – 10 G	
Landing Loads	3 G (any orientation)	
	Ground	Observe
Temperature	-20 C to 30 C	-50 C to -10 C
Humidity	Ambient RH	0% RH
	Launch to Observe = 1 – 2 hrs	
Mass	< 100 kg	

- Requirements Document = 18 pp